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Ancient Cosmic Dust from Triassic Halite

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ANCIENT COSMIC DUST FROM TRIASSIC HALITE. J. Davidson¹, M. J. Genge², A. A. Mills³, D. J. Johnson¹, and M. M. Grady^{1,4}, ¹PSSRI, The Open University, Walton Hall, Milton Keynes MK7 6AA, ²Department of Earth Science and Engineering, Imperial College London, Exhibition Road, London SW7 2AZ, ³Department of Geology, University of Leicester, University Road, Leicester LE1 7RH, UK, ⁴Department of Mineralogy, The Natural History Museum, Cromwell Road, London SW7 53D, UK. (j.davidson@open.ac.uk)

Introduction: Until now micrometeorites have been extracted from limited periods of geological time (up to ~185-Myr-old) providing only a fragmented record of MM flux changes over geological time [1]. Because of preservation problems, we did not think MMs could be recovered from salt deposits (such as halite). Here we report that not only can MMs be found in, and successfully extracted from, halite; they can also provide an estimate of the terrestrial micrometeorite flux. We found that during the Anisian age of the Triassic (~236-239 Myr ago/Ma) the estimated flux of material in a limited size range was much lower than present day. Our results demonstrate that global salt deposits may provide reservoirs of abundant MMs, spanning a larger degree of geological time than we currently have flux data for. Therefore, the systematic extraction of MMs from salt deposits worldwide will provide the opportunity of tracing cosmic dust flux throughout geological time.

Background: The Northwich halite formation is a major saliferous bed within the Mercia mudstone group of the Cheshire Basin [2], a NE-SW trending faulted half-graben in England [3]. The Northwich halite was deposited during the Anisian age of the Triassic (~236-239 Ma) [3] and is exposed at the Meadowbank Mine near Northwich, Cheshire UK.

Methodology: In 1966, a nominal tonne of freshly blasted pink halite was collected from the Meadowbank mine. Batches of varying size were dissolved in distilled water, with the remaining insoluble residue allowed to settle and flow slowly as a slurry along a plastic trough beneath which a number of very powerful magnets were positioned pole upward. Particles were recovered by lifting the trough away from the magnets, washing them into evaporating basins, allowing them to dry and subsequently storing them in a desiccator.

An initial 4kg batch of halite yielded 17 spherulitic particles, while further 100kg batches yielded hundreds. Spherules were picked on the basis of shape and texture that indicated extraterrestrial origin (e.g. the presence of dendrites). For details of sample preparation prior to SEM and EMP analysis, see the methods of Genge et al. [4]. Particle identification was verified by analysis of surface chemistry from qualitative energy dispersive spectra (EDS).

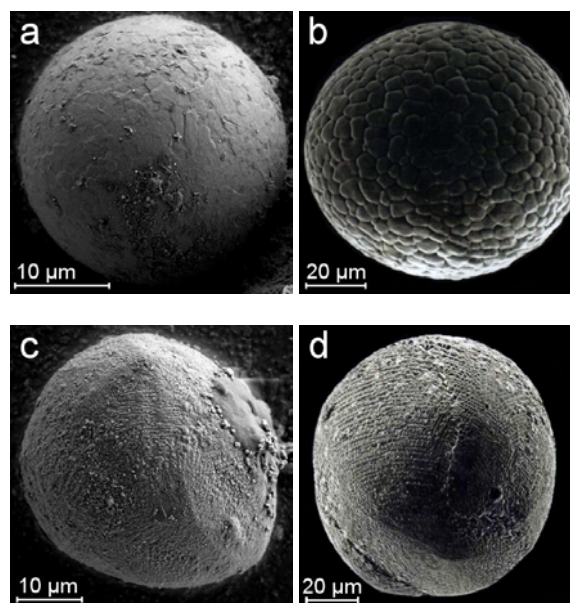


Figure 1. Secondary electron micrographs of Northwich cosmic spherules described here (a, c) and their equivalents in the Antarctic micrometeorite collection (b, d) for comparison. The spherules show characteristic textures (a, b) I-type spherules with hexagonal magnetite dendrites, (c, d) radiating barred-olivine spherules, characteristically non-spherical. When compared to the almost pristine AMMs, the Northwich spherules show evidence for weathering and have been encrusted with small particles (typically gypsum) from the salt. AMMs are from Cap Prudhomme.

Results: Several types of cosmic spherule were found, including; S- (stony), I- (iron-rich), and G- (glassy) types, exhibiting characteristic textures, including S-type barred olivine and cryptocrystalline spherules, G-type spherules dominated by magnetite dendrites in glassy mesostasis, and a variety of I-type spherules with either featureless exteriors or coarse magnetite dendrites (Fig. 1). Several of the identified grains are fragile hollow spherules with vesicles appearing on the surface; this is typical of porphyritic spherules (Fig. 2). The majority of spherules extracted here were within the size range 25-90 μm, which is slightly smaller than those usually reported in terrestrial collections.

Generally, the spherules studied here have undergone significant alteration. I-type spherules are very Fe-rich and give compositions similar to those reported in DSS [5]. It is probable that chemical weathering causes some bias in the chemical composition of recovered Northwich halite cosmic spherules, since most of the silica appears to have been dissolved by salt water. Similarly to collections of DSS, there is a paucity of silicate grains from the halite. Again, this can be explained by weathering during deposition and residency in salt water for a significant period of time.

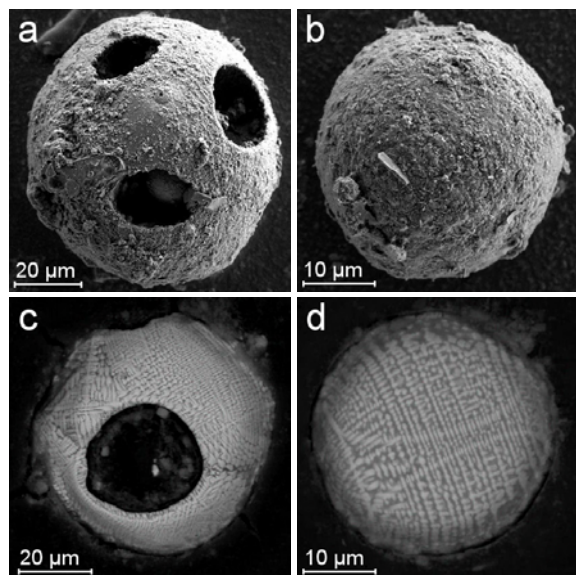


Figure 2. Secondary (a, b) and backscatter (c, d) electron micrographs of Northwich cosmic spherules, including (a, c) a porphyritic S-type, and (b, d) an I-type spherule. The surface of the porphyritic spherule has been significantly weathered. However, both spherules show clear, characteristically extraterrestrial, internal dendrite structures.

Spherule sizes were measured using an optical microscope. These size distributions were converted to cumulative mass distributions (after Murrell et al. [5]) and a flux rate was estimated. For spherules in the size range 25–90 μm we calculated a flux rate of 37 tons yr^{-1} . These are spherules that have survived both atmospheric entry and storage in halite for millions of years. For grains $<100 \mu\text{m}$ various fluxes have been reported previously; from 41 to 2200 tons yr^{-1} , calculated from Taylor et al. [6] and Maurette et al. [7] respectively. Estimates for the overall modern flux rate range from 1,500 [8] to 40,000 ($\pm 20,000$) [9] tons yr^{-1} . Our estimated rate is only $\sim 2.5\%$ of the lowest estimate and, therefore, should be taken as an indication of the mass survival rate of these particles during atmospheric entry and storage for millions of years in halite.

Conclusions: We have demonstrated that CS can be quickly and cleanly extracted from ancient halite. The systematic extraction of micrometeorites from salt deposits, which occur throughout the geological record, may provide the opportunity for tracing changes in cosmic dust flux throughout geological time. Further studies of deposits of varying age and of larger sample sizes, combined with refinement of collection and processing techniques, should provide more reliable flux and compositional data. If compositional data can be extracted from unaltered MMs we may also be able to detect changes in the population of Solar System bodies over time.

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